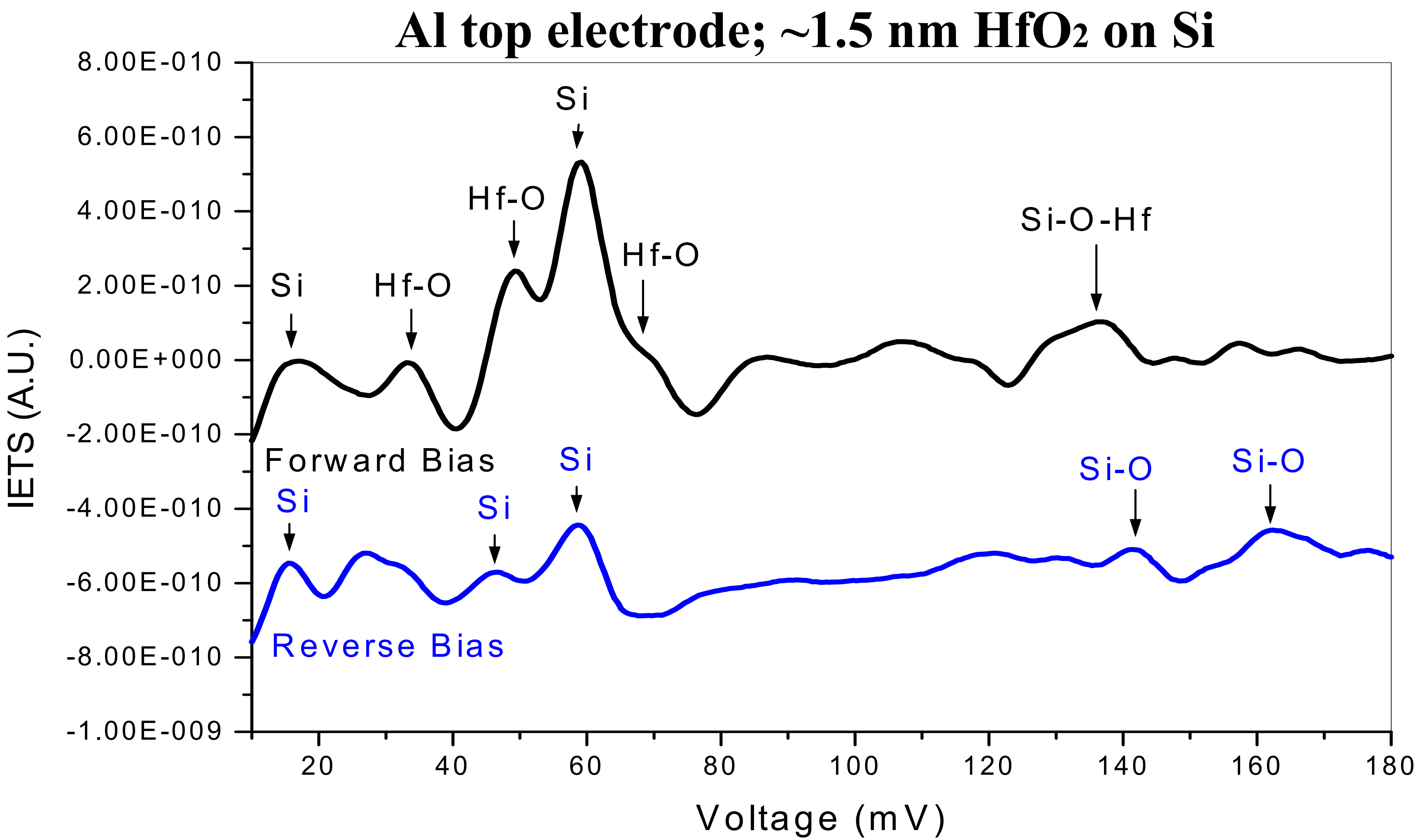
Inelastic Electron Tunneling Spectroscopy (IETS) Study of High-k Gate Dielectrics



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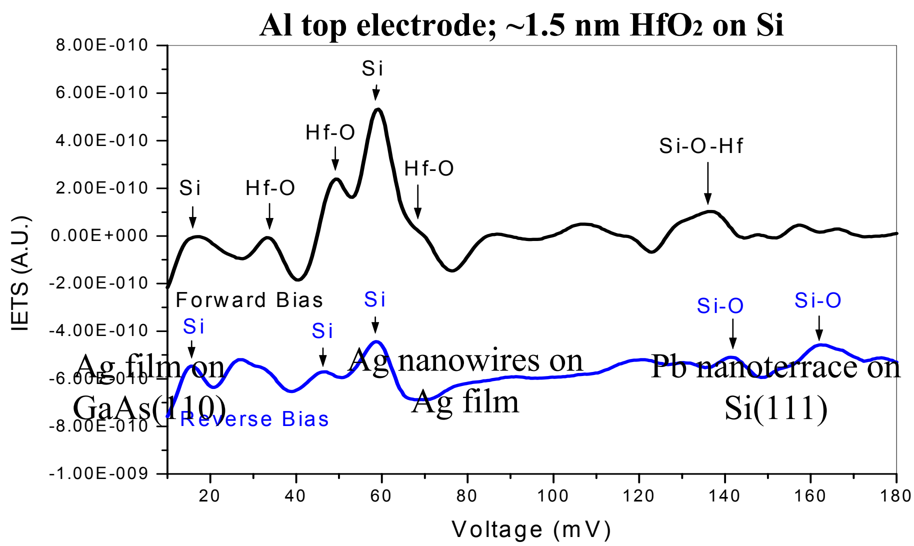

Inelastic Electron Tunneling Spectroscopy (IETS) Study of High-K Gate Dielectrics; T.P. Ma/Yale University; DMR-0096762.

The Si-based semiconductor industry has been able to sustain the "Moore's Law" for more than 3 decades largely because of it's ability to scale down the CMOS transistor dimensions. A key component of the MOS transistor is the gate dielectric, which has now been shrunk down to thinner than 2.0 nm of SiO2, and in a few years it will be so thin that the leakage current through it will render the circuit useless. Therefore, there is a pressing need to find a alternative gate dielectric that has much lower leakage current. The most promising alternative dielectrics are those metal-oxides that have high dielectric constants, the so-called high-k dielectrics, including HfO2, ZrO2, and La2O3. This project uses electron tunneling as a probe to study the bonding structure, defects, and impurities in ultra-thin (< 2nm) high-k dielectrics on Si. The electron tunneling probe is more advantageous than many conventional thin-film spectroscopy tools (such as IR, Roman, and neutron spectroscopy) because the sensitivities of the latter diminish as the film thickness decreases, while the former becomes **more** sensitive as film thickness decreases, which is in the direction of CMOS scaling trend. This particular example shows that, by using two different polarities, the IETS spectra can reveal materials information both near the HfO2/Si interface (lower blue spectrum) and near the Al/HfO2 interface (top black spectrum).